Visit to Fermilab NICADD Photoinjector Laboratory (FNPL)
January 15 - 18, 2002

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Purpose:

- Gain experience with FNPL operations
- Discussions with FNPL staff regarding collaborations and contributions from LBNL
- Discussions with other personnel on topics related to the Femtosource design:
  - 3.9 GHz dipole mode superconducting cavity
  - Cryogenics systems requirements
  - Experience of current FNAL staff from CEBAF
  - Other topics (Pi3)

Facility operations

Photocathode:

- Emission (quantum efficiency) does not rise rapidly vs rf phase.
- Fresh cathode from Milan? Existing cathode ~ two years old.
- System to mount new cathodes needs attention - FNAL person working with Milan. Possible interest from ANL?
- Influence of magnetic field (reduced QE, reduced dark current) not understood. Walter Hartung has worked on this in the past.
- Current spikes observed before / after rf pulse.
- Multi-bunch operation shows large differences in charge per bunch, also energy and energy spread.

Laser

- Transverse and longitudinal diagnostics need improvement.
- FNAL need help with laser expertise to understand and optimize their system, and identify upgrades.
- Pulse stacker needs work (rebuild). Need clean 10 ps pulse, currently very non-uniform distribution. Also want to stack pulses to 30 - 40 ps uniform pulse (avoid space-charge), plus witness pulse.
- Leaving laser on overnight improves stability and up-time.

Screens

Some GaAs, some phosphor. GaAs sensitive to single bunches, but cameras saturate and potential depth-of-field problem (screen ~ mm thick).

We would like ability to see single bunch on each screen.

Need fiducial on screens to determine scale.

What are the time constants for the screens?

Slits

Difficult to orient.

Cameras

Need filters and / or aperture control to avoid saturation. New camera's may be useful? Cooled cameras may improve sensitivity. Integration time settings and requirements need to be understood.

Alignment

Discovered mis-alignment in skew quad, needs attention.

Solenoid alignment scheme developed by Darmstadt group - implement at FNPL.

9-cell cavity alignment, transfer matrix studied, data not fully analyzed.

Need standardized procedures for cycling magnets to improve reproducibility.

BPM's

~ 6 4-button BPM's installed, none connected to electronics. FNAL design converts to 53 MHz signal, expected ~100μm resolution at 1 nC. HERA design electronics may be available, different system using differing delay lines on each button and digitizing each of the four signals, then process.

ALS engineers may be able to help?

Remote operation (GAN)

Most functions accessible remotely, 9-cell cavity cryogenics is not. Netscape, Timbuktu, other systems. Image files needed (images of screens), maybe best to generate files and transfer by FTP.

DESY, ANL also interested.

Need to identify space for "virtual control room" at LBNL.

Analysis of data

Need consensus on analysis techniques - Gaussian / rms / throw away "bad" data …?

Simulations

Femtosource, TESLA, and Smith-Purcell radiation group all need high quality flat beams. Work together on PARMELA / MAFIA / HOMDYN / ASTRA simulations.

Contact between KJ Kim student and Femtosource will be beneficial.

3.9 GHz superconducting deflecting cavity

Leo Bellantoni

FNAL design for kaon separation. Prototype cavity has 13 cells, designed and fabricated at FNAL / Chicagoland industry. Currently bench testing with cavity mounted in tuning frame. Cavity is pressed to provide deformation ("flat" surface on opposite side of the cavity) defining the orientation and splitting the mode degeneracy. ~ 10 MHz difference between modeled frequency and measured. Difficulty understanding modes observed, coupling between π and $12\pi/13$ modes? Tuning very problematic due to coupling of modes.

Talk of building second cavity with fewer cells to avoid coupling of modes.

Test facilities available at FNAL. Vertical dewar, cryogenics plant, diagnostics.

FNAL do not appear to need mode damping, our application will. Our analysis may influence their decision.

Cryogenics systems

Reuben Carcagno, Tom Peterson

Explained basics of cryogenics systems to the uninitiated.

Suppliers of advanced technology are European (Air Liquide, Linde). US may supply other parts of systems and provide design, assembly expertise.

New Dresden facility rated 300W @ 2K, cost $2M - 3M.

Estimate $10m for our requirement of 1.5 kW @ 2K.

4 - 6 compressor stages recommended, each ~ 15 feet square. Compressors, 4K cold box, 2K load may be separated and connected by transfer lines. Transfer line technology well known.

CEBAF experience

Valerie Lebedev

Changed optics to reduce ß-functions. All quads on individual power supplies - important. Symmetry and periodicity is less important.

Beam shaking at 60 Hz allows a differential measurement of beam positions on BPMs. This is used to find a gross discrepancy between theoretical lattice and existing lattice. The locations where something happens are typically seen as spikes in a plot of the Courant-Snyder invariant. With this technique they found some power supplies discrepancies of up to 1%. Residual magnetic field was not properly de-gaussed in some cases. They also found a long time drift of the magnetic field, which was not understood. However, they found the empirical procedure that eliminated the drift. When setting the lattice first they overshot the set point a bit and then stepped down to the right setting.

Lesson: During the magnetic measurements we have to establish the magnetization procedure that will mirror future machine operation and follow it. Magnetic measurements have to include long time recording of the magnetic fields. Since we will have few elements in a "spreader" with a side-to-side location, then we need to do magnetic measurements of these magnets in an actual assembly.
The typical magnitude for the adjustment of the beam launch phase within the RF cycle on every pass through the linac is ±15 degree.
Energy stability is 10^{-5}, achieved by using RF phase modulation with a very small amplitude (fraction of a bunch length) and observation of the first and second harmonic of the energy modulation (perhaps on BPM in a location with a large dispersion function). NB: the must be no first harmonic when the beam is sitting exactly on the crest.

Photoinjector 3 proposal

Jerry Blazey (physics professor Northern Illinois University, leads NICADD consortium) presented very preliminary plans for a new photoinjector facility to be built at Fermilab. The primary interest is in a test facility for the TESLA FEL injector, using a long electron bunch from the gun to reduce space charge effects, linearizing the bunch with a harmonic cavity, and compressing in a chicane.
The proposed facility would include

- New rf gun (could be high rep-rate - LBNL contribution)
- 8-cavity TESLA FEL injector cryomodule supplied by DESY
- 3.9 GHz (third harmonic) accelerating cavity
- Compression chicane
- Diagnostics

Steve Holmes (Fermilab deputy director) attended the meeting and indicated support from the FNAL directorate. An expression of interest is being drafted, with Berkeley to be included.